



# Spatial patterns of southern pine beetle infestations

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## Introduction

- Populations of southern pine beetle, *Dendroctonus frontalis* (Scolytidae) fluctuate from endemic to highly epidemic densities in southeastern United States.
- *D. frontalis* kills healthy pine trees by mass attacking them to overcome their resin defense.
- Infestations of *D. frontalis* (patches of dead and dying pine trees) are non-contiguous within forest landscape.
- Old infestations stop growing during winter and new infestations appear in early summer/late spring.
- Mark-and-recapture study showed that 1/3 of beetles dispersed > 1 km (Turchin and Thoeny 1993).
- During summer, dispersal distances are shorter and beetles respond to host volatiles and aggregate to individual trees and trees adjacent to them leading to infestation growth (Gara 1967, Coster and Gara 1968, Turchin and Thoeny 1993)
- Success of an infestation depends on stand and host tree characteristics and local beetle population density
- If nearby infestations increase the risk of an infestation the following year this may have consequences for forest managers



Southern pine beetle entering a pine tree

Gallery excavation in phloem

Brood developing and feeding on mutualistic fungus



Mass attacked pine tree, small multi-tree infestation and large infestation within a forest landscape.

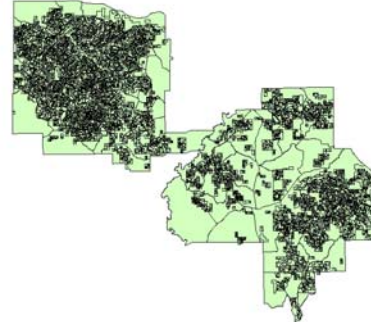
## Hypothesis

The dispersal of *D. frontalis* is limited, and, therefore, the next year's infestations tend to be close to the infestations of the previous year.

## Material and Methods

**DATA:**  
Spatial locations of infestations based on survey flights and ground checks during outbreaks in 1998 – 2000 at the Oakmulgee District of Talladega National Forest.

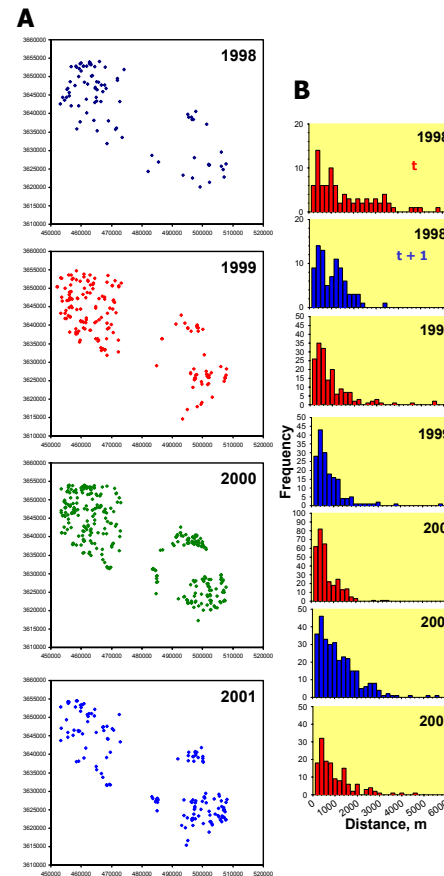
Three nearest neighbors were determined for each infestation within each year (FIG 2).



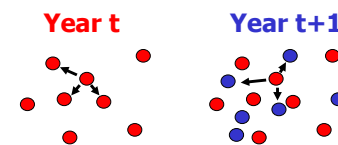
**FIG. 1.** A map of Oakmulgee District of Talladega National Forest in Alabama, USA

### Randomization test:

Distances between three nearest neighboring infestations between year  $t$  and  $t+1$  were calculated (FIG. 2). They were averaged to get an observed **mean nearest neighbor distance** (=test statistic). A randomized distribution to compare the test statistic was compiled by randomly assigning the spatial coordinates of infestation to years  $t$  and  $t+1$  and calculating the nearest neighbor distances and their mean 199 times.



**FIG. 3.** A) Spatial locations of infestations during outbreak years 1998-2000 at Oakmulgee District. B) The distributions of the 1<sup>st</sup> nearest neighbor distances within each year (red bars) and from year  $t$  to  $t+1$  (blue bars).



**FIG. 2.** An illustration of finding three nearest neighbors for a spot within a year  $t$  (red dots) and the following year  $t+1$  (blue dots).

## Results

For the majority of infestations three nearest infestations were located no further than 2 km (FIG. 3).

The three nearest infestations in 1999 were not closer to or further from infestations in 1998 than expected measuring the distances in random (FIG. 3, TABLE 1). Infestations in 2000 and 2001 were, however, significantly further from the infestations of the previous years 1999 and 2000, respectively (TABLE 1).

**TABLE 1.** Results from the randomization tests

From $t$ to $t+1$	Nearest neighbor	Mean distance, m	$P$ -value (2-tailed)	Result
1998 – 1999	1 <sup>st</sup>	907	NS	No difference
	2 <sup>nd</sup>	1482	NS	No difference
	3 <sup>rd</sup>	1924	NS	No difference
1999 – 2000	1 <sup>st</sup>	706	<b>0.08</b>	Further
	2 <sup>nd</sup>	1156	<b>0.01</b>	Further
	3 <sup>rd</sup>	1453	<b>0.02</b>	Further
2000 - 2001	1 <sup>st</sup>	1087	<b>0.04</b>	Further
	2 <sup>nd</sup>	1773	<b>0.02</b>	Further
	3 <sup>rd</sup>	2197	<b>0.03</b>	Further

## Conclusions

The hypothesis that the dispersal of beetles could limit the spatial spread of infestations was rejected: the pattern was, in fact, the opposite.

Our results support the idea that beetles may switch their behavior after summer, perhaps triggered by environmental conditions. The emerging beetles no longer tend to aggregate to neighboring trees. Instead they may have to fly for a certain distance before they become responsive to host volatiles and pheromones again.

Distances between infestations likely depend on epidemic status of the forest. Therefore, we aim to incorporate data from earlier years and other forests to follow the development of outbreaks in space and time.

Further analyses aim to account for:

- control by cutting infested trees
- host species availability
- earlier years in outbreak history